(c) a second deionization means for removing ionized and/or ionizable carbon compounds from the water to form a third product stream containing a smaller concentration of ionized and/or ionizable organic carbon compounds and of non-ionized and/or non-ionizable organic carbon compounds than the first stream; and

(d) a recovery means for recovering the third product stream;

wherein at least one of said first deionization means and said second deionization means is selected from the group consisting of electrically regenerated ion exchange apparatus, electrodeionization apparatus, electrodialysis apparatus, filled cell electrodialysis apparatus and electrodiaresis apparatus.

13. An apparatus according to claim 12 including a recirculating flow loop and wherein the first removal deionization apparatus comprises the second deionization apparatus.

14. An apparatus according to claim 12 wherein one of said first deionization means and said second deionization means is selected from the group consisting of electrically regenerated ion exchange apparatus, electrodeionization apparatus, electrodialysis apparatus, filled cell electrodialysis apparatus and electrodiaresis apparatus and one of said first deionization means and said second deionization means is selected from the group consisting of reverse osmosis apparatus, nanofiltrative apparatus, chemically regenerated ion exchange apparatus, activated carbon apparatus and other sorbent apparatus

REMARKS

Upon entry of the present amendments, claims 1-23 are pending. Applicant has amended claims 1-3 and claims 12-14 to more clearly recite the invention, and the term "removal unit" is amended to more specifically recite the "deionization" units

Attached hereto is a marked-up copy of the claims as amended, showing the changes made. The attached page is captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE". No new matter is added.

The present invention is directed to an improvement in systems for treatment of water to produce an ultrapure product water, for example the water used for advanced manufacturing processes such as semiconductor or pharmaceutical manufacturing. It particularly relates to the removal of organic material.

For many years, water purification plants have employed a general structure of a pretreatment, such as gross filtration, flocculation, settling or the like, followed by demineralization using a number of processes such as pH adjustment and reverse osmosis (RO), electrodialysis, ion exchange beds, or electrodeionization (a form of electrodialysis in which the cells are filled with ion exchange resin). Ultraviolet light is typically used ahead of the final ion exchange resins or membranes, because these materials (particularly anion exchange materials) are prone to biofouling and UV is effective to kill microorganisms that may otherwise colonize the water system. UV has also been found useful for breaking down certain intractable substances, such as larger organics and also materials such as haloalkyl compounds that may arise naturally or from various oxidizers or treatment chemicals added to the water.

To a certain extent, the use of UV is an extension of a long standing practice of treating municipal waters with UV to kill germs, and like that practice it has sometimes been practiced using UV irradiation in conjunction with additional oxidizers to enhance its effectiveness. However, biostatic treatment is a different problem than ultrapurification of water to produce a product substantially entirely free of organic contaminants. In the former case, organic material including living material may be present in higher concentrations, and the targeted biological material may absorb UV relatively strongly over the bands covered by common municipal treatment sources (*e.g.*, 254 or 215 nm mercury sources, or shorter wavelengths.)

When the technique is applied near the output end of a UPW treatment process, however, the concentration of contaminants is already quite low, and may be in the very low sub-ppm range; moreover; the remaining contaminants may include non-ionized and non-ionizable small organic molecules that are not strongly absorbent in a wide UV band, as well as ionized or ionizable material that captures much of that UV light which is present. These factors may render UV irradiation less effective, so that very high intensities or residence times might be necessary to assure sufficient UV absorption and breakdown of the contaminants, and new contaminants may arise in the process. The residual contaminant level is so low, making its

absorption low, and since UV treatment lamps are generally fixed commercial products, one does not generally have the option of, say, increasing the UV intensity 20-fold if the final level of organic material is still too high.

Moreover, the breakdown products may potentially recombine with other components, introducing untreatable reaction products. Even as to the more treatable TOC components, the efficacy of removal will also depend in part on the particular removal affinities of the final treatment being used (*e.g.*, ion exchange, RO, or EDI). For example, ion exchange bottles are generally used as the final polish in a fab plant, and the exchange resin will take up the very small amounts of remaining ionic material present in the polish loop for an extended time before replacement, but may have no effect on certain small molecules. Removal modalities such as RO may reject ions but may pass certain small non-ionic molecules and gases. Membrane-based processes such as RO or EDI may also be prone to both pass, and, to permit back-diffusion of some small molecular components, while electrically regenerated packings as used in EDI may effectively both remove ionic material, and ionize some initially non-ionic materials.

Thus, while many different treatment units have commonly been proposed for water treatment, their performance characteristics all vary, and implementation of an effective organic removal system near the distal end of a treatment line is subject to complex considerations. It is, however, important that the treatment process operate effectively. Applicant has found that by first removing an ionizable portion of TOC before applying the breakdown/ionizing agent, and then applying further deionization treatment, a more effective removal is obtained.

As now more clearly claimed, Applicant's invention addresses these limitation of the art by providing a treatment system for treating a water stream that includes both ionized/ionizable material, and non-ionized or nonionizable material, and wherein the ionized or ionizable material includes some material that becomes non-ionizable when treated with a treatment agent. The system removes a portion of this problem material by applying a first deionization or electrically driven treatment unit before applying UV or chemical enhanced break down or ionization of the rest. This results in more effective UV treatment of the remaining non-ionized or non-ionizable material, so that it is then removed by a deionization device to produce a treated stream having less of both types of organic material than the feed stream. The preferred embodiment is practiced with a UV or chemically enhanced UV treatment between two EDI passages.

Notably, the process is carried out near the outlet end of a treatment line, when a preponderance of impurities have already been removed. Applicant's added treatment ahead of the UV or breakdown agent to first remove at least a part of an interfering portion of the residual TOC enhances treatment and removal of the remaining TOC.

The independent claims are now amended to more clearly recite the invention, and the term "removal unit" is amended to more specifically recite the "deionization" units. The process is clearly an advance over simply applying UV ahead of deionization as taught in the art, and the claims are now believed to be clearly patentable.

Accordingly, Applicants respectfully request that the rejection of the pending claims be withdrawn and reconsidered in view of the amendments to the claims. Applicant also requests that the Examiner reconsider the Applicant's remarks in the Amendment and Response of September 14, 2001.

CONCLUSION

Entry of the amendment and allowance of all claims are now earnestly requested. If any further matter is found to require attention, the Examiner is invited to telephone the below-signed attorney in order to expeditiously address such matter.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES

In the claims:

1. (Amended) A method for purifying water, wherein the water contains ~~removing~~ both (i) ionizable and/or ionized organic carbon compounds and (ii) non-ionized and/or non-ionizable organic carbon compounds ~~from water~~, such method comprising the steps of:

(a) processing a first stream of the water with ~~a first removal apparatus for removing~~ a deionization apparatus to remove from the water ionized ~~and/or ionizable~~ organic carbon compounds and certain organic compounds that are ionizable in said deionization apparatus, wherein at least some of such ionized and/or the certain ionizable organic carbon compounds are susceptible to conversion to non-ionized and/or non-ionizable organic carbon compounds by an agent intended for converting non-ionized and/or non-ionizable organic compounds into ionized and/or ionizable organic compounds, ~~to produce~~ thereby producing a first product stream containing a smaller concentration of ionized and/or ionizable organic carbon compounds including the certain organic compounds, than the first stream;

(b) contacting the first product stream with ~~an~~ said agent for converting non-ionized and/or non-ionizable organic carbon compounds into ionized and/or ionizable organic carbon compounds at a time and a temperature sufficient to form a second product stream containing a smaller concentration of non-ionized and/or non-ionizable organic carbon compounds than the first stream and a larger concentration of ionized and/or ionizable organic carbon compounds than the first product stream;

(c) processing the second product stream with a second ~~removal~~ deionization apparatus for removing ionized and/or ionizable organic carbon compounds from the water to form a third product stream containing a smaller concentration of ionized and/or ionizable organic carbon compounds and of non-ionized and/or non-ionizable organic carbon compounds than the first stream; and

(d) recovering the third product stream from step (c), wherein at least one of said first ~~removal~~ deionization apparatus and said second ~~removal~~ deionization apparatus is selected from the group consisting of electrically regenerated ion exchange apparatus, electrodeionization apparatus, electrodialysis apparatus, filled cell electrodialysis apparatus and electrodiaresis apparatus.

2. (Amended) A method according to claim 1 including a recirculating flow loop and wherein the first removal deionization apparatus comprises the second ~~removal~~ deionization apparatus.

3. (Amended) A method according to claim 1 wherein one of said first ~~removal~~ deionization apparatus and said second ~~removal~~ deionization apparatus is selected from the group consisting of electrically regenerated ion exchange apparatus, electrodeionization apparatus, electrodialysis apparatus, filled cell electrodialysis apparatus, filled cell electrodialysis apparatus and electrodiaresis apparatus, and one of said first ~~removal~~ deionization apparatus and said second ~~removal~~ deionization apparatus is selected from the group consisting of reverse osmosis apparatus, nanofiltration apparatus, chemically regenerated ion exchange apparatus, activated carbon apparatus and other sorbent apparatus.

4. A method according to claim 1, wherein the agent is selected from the group consisting of an oxygen, ozone, singlet oxygen, hydrogen peroxide, chemical oxidizing agent, electrolytic oxidizing agent, electrochemical oxidizing agent, catalytic oxidizing agent, thermal oxidizing agent, and radiation and combinations thereof.

5. A method according to claim 4 wherein the agent comprises radiation characterized by wavelengths of about 184.9 nm.

6. A method according to claim 1 wherein the agent comprises ultraviolet radiation.

7. A method according to claim 6 wherein the agent further comprises hydrogen peroxide.

8. A method according to claim 6 wherein the agent further comprises a catalyst.

9. A method according to claim 6 wherein the agent further comprises a catalyst.

10. A method according to claim 9 wherein the catalyst comprises titanium oxide.

11. A method according to claim 1 wherein the agent comprises ozone and hydrogen peroxide.

12. (Amended) An apparatus for purifying water, wherein the water contains ~~removing~~ both (i) ionizable and/or ionized organic carbon compounds and (ii) non-ionized and/or non-ionizable organic carbon compounds from water comprising:

(a) ~~a first removal apparatus for removing~~ a deionization apparatus to remove from the water ionized ~~and/or ionizable~~ organic carbon compounds and certain organic compounds that are ionizable in said deionization apparatus, wherein at least some of such ionized and/or the certain ionizable organic carbon compounds are susceptible to conversion to non-ionized and/or non-ionizable organic carbon compounds by a conversion means intended for converting non-ionized and/or non-ionizable organic carbon compounds into ionized and/or ionizable organic carbon compounds, ~~to produce~~ thereby producing a first product stream containing a smaller concentration of ionized and/or ionizable organic carbon compounds including the certain organic compounds, than the first stream;

(b) a conversion means for converting non-ionized and/or non-ionizable organic carbon compounds into ionized and/or ionizable organic carbon compounds at a time and a temperature sufficient to form a second product stream containing a smaller concentration of non-ionized and/or non-ionizable organic carbon compounds than the first stream and a larger concentration of ionized and/or ionizable organic carbon compounds than the first product stream;

(c) a second ~~removal~~ deionization means for removing ionized and/or ionizable carbon compounds from the water to form a third product stream containing a smaller concentration of ionized and/or ionizable organic carbon compounds and of non-ionized and/or non-ionizable organic carbon compounds than the first stream; and

(d) a recovery means for recovering the third product stream;

wherein at least one of said first ~~removal~~ deionization means and said second ~~removal~~ deionization means is selected from the group consisting of electrically regenerated ion exchange apparatus, electrodeionization apparatus, electrodialysis apparatus, filled cell electrodialysis apparatus and electrodiaresis apparatus.

13. (Amended) An apparatus according to claim 12 including a recirculating flow loop and wherein the first removal deionization apparatus comprises the second ~~removal~~ deionization apparatus.

14. (Amended) An apparatus according to claim 12 wherein one of said first ~~removal~~ deionization means and said second ~~removal~~ deionization means is selected from the group consisting of electrically regenerated ion exchange apparatus, electrodeionization apparatus, electrodialysis apparatus, filled cell electrodialysis apparatus and electrodiaresis apparatus and one of said first ~~removal~~ deionization means and said second ~~removal~~ deionization means is selected from the group consisting of reverse osmosis apparatus, nanofiltrative apparatus, chemically regenerated ion exchange apparatus, activated carbon apparatus and other sorbent apparatus

15. An apparatus according to claim 12 wherein the conversion means comprises contact means for contacting the first product stream with an agent.

16. An apparatus according to claim 15 wherein the agent is selected from the group consisting of a oxygen, ozone, singlet oxygen, hydrogen peroxide, chemical oxidizing agent, electrolytic oxidizing agent, electrochemical oxidizing agent, catalytic oxidizing agent, thermal oxidizing agent, and radiation.

17. An apparatus according to claim 16 wherein the oxidizing agent comprises radiation characterized by wavelengths of about 184.9 nm.

18. An apparatus according to claim 16 wherein the oxidizing agent comprises ultraviolet radiation.

19. An apparatus according to claim 18 wherein the agent further comprises hydrogen peroxide.

20. An apparatus according to claim 18 wherein the agent further comprises ozone.

21. An apparatus according to claim 20 wherein the agent further comprises a catalyst.

22. An apparatus according to claim 16 wherein the catalyst comprises titanium oxide.

23. An apparatus according to claim 15 wherein the agent comprises ozone and hydrogen peroxide.